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REPORT

OF THE

NATIONAL SCIENCE FOUNDATION

TO THE

CONGRESS OF THE UNITED STATES

CONCERNING A

GEOPHYSICAL INSTITUTE IN THE TERRITORY OF HAWAII

(Executive Communication No. 817)

APRIL 30, 1957

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LETTER OF SUBMITTAL

NATIONAL SCIENCE FOUNDATION,
OFFICE OF THE DIRECTOR,
Washington, D. C., April 30, 1957.

Hon. SAM RAYBURN,
Speaker of the House of Representatives,
Washington, D. C.

MY DEAR MR. SPEAKER: The enclosed report is respectfully submitted pursuant to Public Law 909 (84th Cong., 2d sess.), enacted August 1, 1956, which directed the National Science Foundation "* * * to conduct an investigation into the need for and the feasibility and usefulness of a geophysical institute located in the Territory of Hawaii * * *", and to submit its report and recommendations to the Congress within 9 months.

Sincerely yours,

ALAN T. WATERMAN, *Director.*

REPORT OF THE NATIONAL SCIENCE FOUNDATION TO THE CONGRESS OF THE UNITED STATES CONCERNING A GEOPHYSICAL INSTITUTE IN THE TERRITORY OF HAWAII

Public Law 909, 1956, directs the National Science Foundation to conduct an investigation into the need for and the feasibility and usefulness of a geophysical institute located in the Territory of Hawaii, and to submit its report of this investigation to the Congress within 9 months. The attached report is in compliance with the directive.

By August 1956 the Foundation already had on hand numerous background documents, including letters and commentaries, on the proposed institute in the Territory of Hawaii. In addition, the Foundation appointed the following special advisory committee to study the problem:

Dr. E. A. Eckhardt, Chairman of the Committee; vice president, Gulf Research & Development Co. (retired).
Dr. John C. Warner, Vice Chairman of the Committee; president, Carnegie Institute of Technology.
Dr. P. H. Abelson, director, geophysical laboratory, Carnegie Institution of Washington.
Dr. Carl Eckart, Scripps Institution of Oceanography.
Dr. Leo Goldberg, department of astronomy, University of Michigan.
Dr. Cecil H. Green, president, Geophysical Services, Inc.
Dr. Harry H. Hess, chairman, department of geology, Princeton University.
Dr. M. King Hubbert, Shell Development Co.
Dr. Sverre Petterssen, department of meteorology, University of Chicago.
Dr. W. W. Rubey, United States Geological Survey.

The special committee met several times in plenary session during the fall of 1956 and in January 1957. In addition, subcommittees held independent meetings and contacted numerous scientists throughout the country. A subcommittee visited the Territory of Hawaii in December of 1956 to obtain firsthand knowledge of the local situation.

The unanimous report of the committee was submitted to the Foundation by Chairman Eckhardt in January 1957.

The report has been reviewed by the Foundation's staff, its Advisory Panel for Earth Sciences, and its Divisional Committee for Mathematical, Physical and Engineering Sciences. After thorough consideration by the National Science Board in March 1957, the final recommendations of the National Science Foundation are as follows:

A. SPECIFIC QUESTIONS RAISED IN PUBLIC LAW 909

Public Law 909 states—

> In conducting such an investigation the Foundation shall give particular attention to—
>
> (*a*) the benefits to the Federal Government which would arise from the establishment and maintenance of such an institute;
>
> (*b*) the appropriateness of financing by the Federal Government, in whole or in part, of the establishment or of the establishment and maintenance of such an institute;
>
> (*c*) if such financing by the Federal Government appears appropriate, the agency or agencies of the executive branch to which appropriation should be made and upon which directional authority should be conferred; and
>
> (*d*) the extent, if any, to which such a geophysical institute should be a part of or otherwise related to the University of Hawaii.

B. ANSWERS TO SPECIFIC QUESTIONS OF PUBLIC LAW 909

(Subheadings are designated with same letter symbols as the questions.)

In answer to these questions the Foundation advises:

(*a*) The Federal Government would be benefited by—

1. the development of new scientific information which would be important to the defense and well-being of the Nation;
2. the availability of an appropriate scientific center in a large geographic area of great interest to the United States;
3. the training of scientists now in short supply in the important fields of earth sciences;
4. the probable impact on the development of the island economy, which could be of both direct and indirect benefit to the United States as a whole;
5. the direct benefit to the local offices of several Government agencies that conduct both research and operations in the Pacific area.

(*b*) Financing by the Federal Government would be appropriate because—

1. the resulting benefits would be general as well as local in character;
2. the scientific value of such an institute in Hawaii has been recognized there for some time, but the limited population and economy of the island cannot afford the costs of both establishment and maintenance. The provision of funds to cover operating and maintenance costs alone, however, appears to be within the local capacity; and a grant to support the establishment of the physical plant of such an institute would (and should) entail no continuing obligation of Federal funds for maintenance and operation;
3. the Federal Government would be a direct, even possibly the greatest, beneficiary from the existence of such an institute.

(*c*) An appropriation to support the establishment of such an institute could be made to the National Science Foundation which is already authorized to expend funds for such purposes.

(*d*) A geophysical institute established in the Territory of Hawaii should be a part of and under the control of the University of Hawaii.

C. FURTHER RECOMMENDATIONS

The Foundation further advises that:

1. There are valid scientific and related geographical and educational reasons for the establishment of an institute of geophysics in the Territory of Hawaii.

2. The cost of the physical plant for such an institute is estimated to be about $2.5 million.

3. (*a*) The research potential of the supporting science departments of chemistry, physics, mathematics and geology needs further strengthening so as to assure adequate interdisciplinary competence and backstopping for the institute.

(*b*) Continuing local support should be of sufficient magnitude to assure successful operation.

(*c*) Accordingly, if an appropriation for the establishment of a physical plant of such an institute is made to the National Science Foundation, the Foundation would not obligate funds until it was satisfied that the above conditions were met.

4. Although there is good scientific justification for the establishment of a geophysical institute in the Territory of Hawaii, the institute would not receive support at this time from the Foundation's regular budget because of the many urgent demands being made on the Foundation for the support of scientific research needs of a higher priority.

5. A special appropriation for this purpose should be made, therefore, if the Congress determines that the institute should be established at this time.

DISCUSSION

1. General

Geophysics as used in this report should be understood to mean the physics and chemistry of the earth, including not only the solid earth but the oceans and atmosphere as well, plus such phenomena as the gravitational, electric, and magnetic fields and the radiations that are received from without.

The role that geophysics plays in our national welfare scarcely needs detailed exposition—man's welfare increases in direct proportion to his knowledge of his environment. Our ability to predict the weather depends upon our knowledge of the physics of the atmosphere and the oceans; our ability to transmit radio waves depends upon our understanding of the complex and variable electrical effects produced by the sun's radiation in the upper atmosphere; earthquake prediction and the protection of buildings from damage depend on our knowledge of seismology—that is, the physics of earthquakes. All precise land measurements as well as high-speed navigation of both aircraft and long-range missiles depends upon an exact knowledge of the shape of the earth, of the distribution of its gravitational and magnetic fields, and of the manner in which these fields vary because of the sun and the moon. Our ability to find new sources of mineral wealth necessary for our civilization will depend directly on an increase in our knowledge and appreciation of the physical and chemical processes that operate within the earth's crust; the search for mineral resources such as petroleum and certain metallic ores is even today carried on by the use of applied geophysics.

There can be little serious argument that a healthy development of geophysical science is of direct benefit to the people of the United States and is, therefore, of direct concern to the Federal Government. Yet today great and interesting problems in the earth sciences remain untouched, let alone solved. The big question, therefore, is not "Is a greater effort in geophysics desirable?" but rather "In what ways can more and better geophysical research be stimulated and supported?"

Two very obvious methods of attacking the problem are the establishment of better equipped laboratories for geophysical research, and the development of integrated curriculums of earth sciences in the universities so that more and better geophysicists will be produced. A well-integrated curriculum in geophysics or earth sciences is obviously possible at any first-class university, and indeed many of our universities have taken active steps toward the reorientation of their courses in this field. Many more universities should be encouraged to do so, for only in this way will we ultimately solve the problem of the current deficiency of competent geophysicists. Likewise, good laboratory facilities are feasible at many universities.

In addition to the above need, however, geophysical work often requires what might be called the best available "natural laboratory." Ordinary laboratory work is inadequate in many geophysical problems because of the scale of the phenomena to be observed. Many problems can best be studied by searching for natural conditions which remove some of the complicating variables and which most closely approximate the conditions which the scientist would specify if he could create in his own laboratory. Literally the world is the laboratory of the geophysicist and he must often travel great distances in search of suitable sites for his studies. Certainly, then, a good or proper situation for a geophysical center is one that is close to a great number of desired natural conditions in their most varied combinations, where at the same time facilities exist to exploit the possibilities of research. Such places are few in number; Hawaii is one of them.

2. Geographical advantages of Hawaii for geophysical studies

Because of their unique position near the center of the world's largest ocean and at the northern edge of the Tropics, and because of their remarkable geologic character, the Hawaiian Islands offer great opportunities for investigations of far-reaching importance to an understanding of the weather, the currents, and food harvest of the ocean and the structure and history of the solid earth. Moreover, they constitute our most important outpost in the Pacific. Their location makes them a key point for geophysical studies that require a worldwide net of observations and their particularly varied topography and climate and their geological character offer opportunities for specific studies that are not matched in many places in the world.

It is not often realized that the island of Hawaii, the largest of the group, is actually the highest mountain on earth. Its base is more than 17,000 feet below sea level and the summits of its great volcanoes, Mauna Loa and Mauna Kea, are nearly 14,000 feet above the ocean. Mauna Kea has not been active in historic times but Mauna Loa is the most active volcano in the world, both in terms of frequency of eruption and of volume of lava. During the last 50 years it has spewed forth as much lava as all the rest of the volcanoes in the world combined.

The Hawaiian Islands present topographic barriers of varying heights athwart the northeast trade winds, which causes extreme differences in climate; one can pass from a lush tropical jungle that receives more than 400 inches of rainfall a year to a desert with less than 5 inches of rain, all within the space of 10 miles. Temperatures likewise range from warm subtropical along the coastal areas to cold temperate on the high mountaintops.

Hawaii is also our nearest base to the potentially rich fisheries of the equatorial waters, and the development of marine resources around the islands is practical and necessary for the welfare of the Territory's people.

The location is also ideal for certain studies of the upper atmosphere which cannot be made at temperate latitudes but which must be carried on if we are going to understand the far upper atmosphere with its influence on terrestrial magnetism, radio propagation, weather and climate. More specifically the Hawaiian Islands are especially suited to research in the following geophysical subjects:

(*a*) *Meteorology.*—Although the low latitudes are acknowledged to be the main source of heat for the atmosphere, up until 10 years ago the hypothesis prevailed that one could consider the heat sources as constant, and most meteorological effort was devoted to the Temperate Zone which was thought to contain all interesting weather. Only recently have meteorologists begun to realize that the tropical heat source is far from constant and that the variations are probably of paramount importance in general atmospheric circulation. The study of tropical meteorology is not only of long-range value to theoretical meteorologists; it is of vital importance to our military and civilian operations in the Pacific today. Actually, one of the first statements of the need of a geophysical institute in the Pacific came from General Moorman, then commander of the First Weather Wing, United States Air Force, Tokyo. The lack of a knowledge of meteorology of the Pacific was a serious handicap to the operations of the occupation forces in Japan and it was obvious that we needed a much better understanding of the meteorology of the Tropics especially in connection with the development of typhoons and the interplay between tropical and temperate air masses. Currently, the United States Weather Bureau, Air Force and the Navy, as well as the commercial airlines, are vitally interested in daily forecasts over the Pacific and all have emphasized the need for basic research in this area. The local officials of these agencies have strongly endorsed the geophysical institute of Hawaii as the best method of centralizing and encouraging such basic research.

Hawaii also offers the finest location in the Pacific for the study of trade winds and their modification as they cross topographic barriers. Flow of air over mountains is a complicated subject anywhere, and the theoretical research on this topic is among the most difficult in meteorology. Many factors are of importance—the size and shape of the mountains, the angle of incidence of the air, the velocity of the air, and the stability of the air, including the presence or absence of temperature inversions. Hawaii offers a varied laboratory with respect to all of these. Gathering of suitable data here may lead to the solution of many of the mountain problems and the attendant peculiarities of rainfall not only in the Pacific Islands but on the continent of the United States as well. Trade winds drive low clouds below an

inversion layer against the northeast sides of the islands. As the air rises up the flanks of the mountains moisture is squeezed out, drenching the northeast slopes. Then as the air passes over the crest of the ranges it expands and dries out, leaving the lee slopes semiarid and sparsely covered by vegetation. This is one of the few places where the actual precipitation from clouds can be studied from the ground rather than from an airplane, and it is thus an excellent location to study the effects of artificial nucleating agents in the production of rainfall.

Hawaii is the only major Territory of the United States that is situated beyond the meteorological control of a major continental mass and as such is the only place from which we can conduct studies of the effects of the tropical oceans on both the general circulation of the atmosphere and on the variability of oceanic rainfall. Oceanic rainfall is as variable as that over the continents, witness the fact that more than two-thirds of the annual rainfall in the sugar and pineapple districts of Hawaii is produced by 10 disturbances on the average. Failure of 1 or 2 of these to materialize in a given year will markedly reduce a year's precipitation. Moreover, these "disturbances" are not the typical cyclonic low pressure systems that characterize the temperate zones, but are the result of interplay between the tropical and temperate air masses or of local irregularities in the streamline flow of the tropical air, and the causes are poorly understood.

(*b*) *Volcanology.*—As stated above, Hawaii has the largest volcanic mountains in the world and the most active volcano in the world today. Moreover, the Hawaiian volcanoes are comparatively "tame" in that their eruptions are quiet, involving the outpouring of huge quantities of liquid lava rather than explosive and destructive eruptions such as characterize volcanoes like Vesuvius or Pelée. The Hawaiian volcanoes are the most accessible of the world's tame volcanoes, and are therefore the most easily studied.

Even if there were no practical aspects to the subjects, scientists would still study volcanoes as they would every other phase of nature. However, the study of volcanoes can be of great benefit in at least two fields. Many of our important metallic ore deposits are believed to have been concentrated in the earth's crust by processes related to volcanism. These processes can be studied in post mortem phases in the mining districts of the world, but only at active volcanoes and hot springs can there be made direct "clinical" studies of the processes. Better knowledge of the processes that formed the deposits will aid in the search for new ore bodies. Another growing field is that of the utilization of volcanic energy. Steam has been utilized in the volcanic areas of Italy and New Zealand. Still in the future, but by no means impossible, is the eventual direct harnessing of volcanic heat. Hawaii offers an excellent laboratory for such studies.

The humanistic aspect of volcanology involves the saving of human lives and property. This has been one of the great preoccupations of volcanic studies in Hawaii. Since the volcanoes in these islands are easily approachable and since continuous observations of them can be made both in eruption and in repose, the Hawaiian Islands offer an excellent site for the development of methods that can predict volcanic eruptions, not only here but elsewhere in the world. Some success has already been achieved by the Geological Survey in predicting the eruptions of Mauna Loa and Kilauea but much more

research remains to be done. Obviously the successful prediction of a destructive explosive eruption, such as occurred in the Philippine Islands in 1949, would save many human lives and be well worth the cost of the research. Other problems in humanistic volcanology include the control of lava flows through aerial bombing or the construction of barriers, the development of measures to counteract the effect of volcanic fumes, and the development of criteria for depicting areas of a special danger on the flanks of any volcano.

(*c*) *Seismology.*—is one of the principal tools used to study earthquakes and to gain knowledge of the physical character of the earth's interior. The many shallow-focus earthquakes caused by the subterranean movement of molten rock in the Hawaiian Islands make this a good "laboratory" for the study of the physics of earthquakes. Moreover, Hawaii's location in the central Pacific makes it a key point for the recording of more distant and deep-focus shocks that originate elsewhere in the Pacific area. Recording stations are scattered around the edge of the Pacific, both in Asia and in the Americas, but Hawaii is the only midocean recording point. The Coast and Geodetic Survey operates a seismograph station near Honolulu for this purpose, and it has been indicated that the establishment of a good geophysical institute at the university would aid their work in seismology. This prediction is based on the experience gained in Alaska, where the establishment of the Institute of Geophysics at Fairbanks was of direct benefit to the Survey's magnetic observatory.

(*d*) *Geology.*—The structure of island arcs is of great importance in the study of the development of mountain chains. The Hawaiian Islands constitute a chain of volcanic mountains that stretch along a major rift zone in the floor of the Pacific Ocean. The study of the structure of this rift zone and of the rocks themselves can be very important in the realm of structural geology. Such studies, which can be grouped under the heading "tectonics," will include not only geology and petrology but also gravity, magnetic studies, and seismology.

(*e*) *Hydrology.*—Some 200 billion gallons of water are drawn yearly from the ground-water supply of the islands for use of the plantations, factories, and houses in the Hawaiian Islands. Because of its vital importance to the economy, a considerable amount of study has already been devoted to the ground-water geology and hydrology of the islands. These studies, however, constitute only a beginning. It is known, for example, that most of the ground water in the Hawaiian Islands is a fresh water lens that literally floats upon the deeper salt water. This lens, called the Ghyben-Herzberg lens, constitutes the main source of water supply for the islands. The original premise, based on the principle of hydrostatic pressure, was that the base of the fresh water lens extends 40 feet below sea level for every foot that the top is above sea level. However, it has not been demonstrated that this approximates natural conditions only very crudely. Actually, the Ghyben-Herzberg lens represents a complicated problem in hydrodynamics rather than simple hydrostatics, and the development of an adequate dynamic theory will be of crucial importance to the evaluation of the ground-water resources in Hawaii and other islands as well. The detailed studies of the geology and groundwater levels on the island of Oahu make this area especially favorable

for theoretical studies of hydrodynamics as applied to the Ghyben-Herzberg principle.

(*f*) *Astrophysics and cosmic radiation.*—The Hawaiian Islands contain some of the highest mountains in the world in the middle latitudes and in a marine area. Moreover, the tops of these mountains are well above trade wind inversion layer and are thus in clear, relatively dry air a large part of the time. This makes them ideal for the observation of the effects of cosmic radiation in the midlatitude impact zone. Studies made at this latitude and longitude will be a valuable corollary to studies made in the temperate and Arctic regions. The same conditions make the Hawaiian Islands favorable for the study of solar radiations and for radio-astronomy. It is now fairly well established that the solar magnetic storms and possibly other types of solar radiation control certain variations in the ionosphere, triggering off such phenomena as the aurora. It is also well know that these variations are an extremely serious practical difficulty in long-range radio communication, and that the study of the ionosphere at different latitudes and longitudes, will eventually have great practical bearing on long-distance communications. It is vital that we have constant communication with outer radar stations at all times, regardless of ionospheric conditions, and ground cables to many of these stations are frequently impractical if not impossible.

(*g*) *Tropical weathering and erosion.*—The importance of knowing more about the processes which produce soil and those which wash it down to the sea is evident. The Hawaiian Islands offer in a small and compact territory an opportunity to study the problems of runoff and erosion under all conditions from humid to arid and on slopes that range from gentle and nearly smooth to steep and rugged. In addition, the problems related to sedimentation along the seacoast are easily attacked in this area. The islands also offer an unparalleled place for the study of soil development. The volcanic rocks which comprise these islands are all comparatively recent, geologically speaking, but of varying ages from island to island. The rates of soil development and the chemical processes involved are more easily studied here than anywhere else in the United States and its Territories. For example, it will be possible on the island of Hawaii itself to study the soil development on historically dated lava flows that extend through several distinct climatic zones. On the northeast flank of Mauna Loa flows that were poured out during the latter half of the 19th century extend from the cold arid zones near the tops of the mountains down to a lush tropical rain-forest along the east coast of the island. In the warm moist regions at lower altitudes these flows already support a considerable amount of vegetation, but in the cold arid upper altitudes they appear to be as fresh and unweathered as the flows of 1949 and 1950.

The study of the processes of soil development in the islands is also of practical importance in the understanding of the development of mineral deposits that are concentrated by residual weathering. Such deposits include all of the world's known aluminum ores and some of its large deposits of iron. The comparatively recent discovery of huge tonnages of low-grade aluminum ore on several of the islands has emphasized the need for more studies of this type. These deposits, although low grade in comparison to those that are now mined elsewhere in the world, include many millions of tons and constitute the

greatest potential reserve of aluminum ore in the United States or its Territories. The study of the chemistry of development of these deposits, some of which may still be in the process of formation, will be of value not only to economic geology, but also to studies of plant nutrition.

(*h*) *Marine studies.*—The Hawaiian Islands provide a Pacific base for oceanographic studies both for the sake of science itself and for the direct benefit to related meteorological studies and to the fishing industry. The University of Hawaii already has a marine laboratory which emphasizes ecological studies, especially of the marine organisms that live near shore. "Inshore oceanography" is important for marine biological research, especially in relation to the search for spawning and nursery grounds of many organisms including those that are used as bait fish for tuna. Detailed knowledge of water movement within the bay areas of the Hawaiian Islands coupled with synoptic observations of temperature and salinity will be necessary before there can be a full understanding of the factors involved in the distribution and population density of these fish. Similar information might enable biologists to predict inshore and offshore movements as well as the sudden appearance and disappearance of submarine species. The establishment of a geophysical research center at the university would fill a big gap in the program.

The Pacific Oceanic Fisheries Investigation (POFI), a part of the Fish and Wildlife Service, currently conducts deep-sea oceanographic work in relation to the distribution of tuna and other commercial fish crops. The new building of the Fish and Wildlife Service is located on the campus of the university and there is a close cooperation between the university staff and staff of the POFI. The Fish and Wildlife personnel in Honolulu are unanimous in their endorsement of an expansion of geophysical research facilities at the University of Hawaii, and point out numerous specific examples where it would be of direct benefit to their work.

Tsunamis are large destructive waves that constitute a menace to all island areas of the Pacific Ocean. They are apparently generated by submarine faulting and earthquake shocks in parts of the Pacific and then travel in waves as much as 20 or 30 feet high for many thousands of miles. Thanks to the cooperative efforts of the Geological Survey's Volcano Observatory, the Coast and Geodetic Survey's observatory at Barbers Point, the United States Weather Bureau and the University of Hawaii, a tsunami warning system for the central Pacific has been put into operation and can predict the arrival of these ocean waves with a fair degree of accuracy. This is, however, only a beginning and more basic research is needed.

3. Educational benefits

The Foundation's advisory committee stated emphatically that one of the most pressing needs in the field of geophysics today is the production of more and better trained young geophysicists. Therefore, the training of young scientists should be a prominent activity of any institute such as is proposed in Hawaii. Training such as is needed can be provided by the proper curriculum at any major university in the United States, and admittedly Hawaii, because of its geographic isolation from the mainland, would not be the first place where an institute should be established if classroom training were its

only mission. However, much more is involved in training than merely the teaching of courses. The natural laboratory provided by the Hawaiian Islands would make this an excellent locality for the teaching of future geophysicists. Moreover, the isolation from the mainland is probably not as serious as might be anticipated. The same objection was raised to the establishment of the Institute of Geophysics at the University of Alaska. Yet, within its first 10 years of operation it has attracted a number of first-rate students and faculty members and has produced several very competent research workers specializing in ionosphere studies. Moreover, the Hawaiian Islands represent a potential source of new scientific manpower for the United States. Because of financial reasons, most of the young students in Hawaii cannot afford to journey stateside for their education and therefore must be trained locally. An expansion of the training and research facilities in all sciences at the University of Hawaii is therefore desirable. The resulting graduates would be important not only to the Territory but would also constitute an important reserve at a time when we are short in scientific and engineering manpower. This is substantiated by the fact that more than half of last year's University of Hawaii graduates in engineering accepted positions in various part of the United States mainland.

4. Relations to the University of Hawaii

A geophysical institute such as the one being developed in the Territory of Hawaii must be closely associated with and form an integral part of a good university, partly because the training of students is a valuable product of such an institute and partly because the teaching of students is a stimulant to the staff of the institute. The University of Hawaii and the other local supporters in the Territory are in complete agreement with this concept.

The university proposes to staff and operate the institute on a basis that members of the institute's permanent staff shall also be members of the appropriate departments in the university and that their salaries will be paid entirely by the university and will not be dependent on any outside funds for research grants or contracts. This should provide a stable base of operations. Teaching loads will be reduced in proportion to the time spent in research work. This system of reduced teaching loads to allow for research is already a university policy. It assures competent scientists of an opportunity to do research without being overburdened with teaching. The custodial care of the physical plant of the institute would be undertaken by the university as a part of its regular maintenance program. Outside funds would be sought only to finance the costs of specific research projects. The Foundation considers these plans sound and reasonable.

5. Supporting research activities at the University of Hawaii

To achieve maximum utility as an effective instrument of scientific research a geophysical institute must be associated with a university that has strong departments in the basic physical sciences of mathematics, physics, chemistry, and geology. The University of Hawaii has some serious weaknesses in these departments. If this were a static condition, the Foundation would not recommend against Federal aid for a geophysical institute in Hawaii, but the situation is far from static. During the last 3 years, under the able leadership of Dean Robert W. Hiatt and the late President Paul Bachman, the

university has been making a serious and determined effort to improve its teaching and research potential, especially in the field of the sciences. Several highly competent men have been added to the permanent professional staff and form the nucleus of a good research staff. Also, the university has an informal exchange agreement with Scripps Institution of Oceanography, and this year Dr. Han Pettersson and Dr. Norris Rakestraw are at the university teaching courses in physical oceanography and sedimentology.

That the university is continuing its efforts to strengthen the departments of the basic physical sciences is evidenced by the fact that the budget for the coming biennium for teaching and research in these departments has been increased substantially over the last biennium—$462,000 for 1955–57 and $559,000 for 1957–59. Also, a bill to provide $85,000 for the direct support of the institute is now being considered by the Territorial legislature, this amount to be used for salaries of a director and one other scientist, plus clerical and technical assistance.

The Foundation's advisory committee was impressed with the efforts of the university to build these departments to the necessary strength. Moreover, it is the belief of the university that the establishment of a good physical plant for its geophysical institute will aid in the strengthening of the departments of physics, mathematics, and geology, especially since the staff members of the institute would also be members of these departments. This has happened at the University of Alaska, where the establishment of the Institute of Geophysics by the Congress led to an immediate and pronounced strengthening of the physical science departments. It is reasonable to assume that the institute in Hawaii would have a similar beneficial effect.

It has also been argued by some that because of the isolation it will be difficult to staff the institute with high caliber personnel. The same argument was raised in connection with the Alaskan institute and has proved overly pessimistic. Moreover, in this age of air travel, Hawaii is a crossroads and receives numerous visitors, so that it is no longer the isolated locality that it was several decades ago. The proposed institute in Hawaii would be available to visiting scientists from educational institutions on the mainland and to the staffs of Federal agencies. The University of Hawaii encourages exchange of professors with mainland institutions, and the establishment of a physical plant for the institute would stimulate this healthy exchange still more.

6. Local support outside the University of Hawaii

Due largely to its isolated position in the Pacific Ocean the University of Hawaii has become the focal point for cultural and scientific activities of the whole area. It occupies a position of leadership in local activities that is far greater than most mainland universities. There is close cooperation between the university, various Federal bureaus, and the excellent private industrial laboratories of the Pineapple Research Institute and the Hawaiian Sugar Planters Association. Senior research men from the staffs of both institutions are faculty associates in the graduate school of the university. The courses taught by the Air Weather Service to its meteorologists are conducted at the university and in cooperation with the university's

staff. The Fish and Wildlife Service has a new building on the campus and works in close cooperation with the university. Likewise, the local representatives of the United States Weather Bureau, United States Coast and Geodetic Survey, and the United States Geological Survey maintain close liaison with the university. The Hawaiian offices of each of these Federal agencies and each industrial association were vigorous and enthusiastic in their endorsement of a geophysical institute at the university. Everyone contacted by the special committee felt that the new institute would be of great benefit to his own work and promised cooperation and support of the institute's activities. It is probable, for example, that some of the work of the Hawaiian Sugar Planters Association would be transferred to the new institute with appropriate monetary support. The Federal agencies would continue to work in close cooperation with the university in general and the institute in particular. The institute would be of particular benefit to the United States Weather Bureau and the Air Weather Service of the United States Air Force, both of whose local staffs have strongly urged the institute and have pledged enthusiastic and strong cooperation.

7. Cost of the institute

The original plans, drawn several years ago, visualized a cost of $1 million for the construction and equipping of a geophysical institute in Hawaii. However, a careful study of the plans by the Foundation's special committee and by the university's committee on geophysics, led to the conclusion that the institute as proposed would not be of maximum effectiveness in that it failed to include adequate space for student laboratories and training facilities. The university has, therefore, restudied the problem and prepared a revised cost estimate that can be summarized as follows:

Building cost:	
1. Main laboratory and administration unit (including laboratory and training space for geology, hydrology, volcanology, oceanography, meteorology, geochemistry and astrophysics, plus the necessary shops, library, and lecture rooms) 65,000 square feet at approximately $22 per square foot	$1,430,000
2. Auxiliary buildings including high altitude laboratory, seismology vault, hydraulics laboratory, and housing for visiting scientists	120,000
3. Landscaping, driveways, parking areas, etc	30,000
4. Built-in mechanical equipment	20,000
5. Contingency item	40,000
6. Professional fees	112,000
Total estimated building cost	1,752,000
Cost of equipment:	
1. Scientific equipment for various laboratories mentioned above	425,000
2. General equipment and facilities including shop equipment, laboratory and office furniture and an electronic analog computer	215,000
Total cost of equipment	640,000
Total estimated overall cost of buildings and equipment	2,392,000

The Foundation believes that these cost figures are reasonable and would provide a physical plant that could be of effectiveness both in research program and in the training of new scientists. The Founda-

tion therefore recommends that any appropriation by Congress for the construction and equipping of this institute be in the order of $2½ million.

8. Summary of discussion

1. There are valid scientific reasons favoring the establishment of a geophysical institute in the Territory of Hawaii, largely related to the geographic position of the Hawaiian Islands near the center of the North Pacific Ocean and at the edge of the Tropics. Because of this position, the islands are a key point for observing certain geophysical phenomena that require a widespread net of synoptic measurements. Also their distinctive geology and varied topography make the islands better suited than any other area in the United States or its territories for the study of certain geological and geophysical processes.

2. The institute would combine research and training of students, thereby providing a new source of scientific manpower for the several fields of earth sciences.

3. The institute should and would be an integral part of the University of Hawaii; its permanent staff would hold faculty positions and their salaries would be paid by the university. Maintenance and operating costs would be the responsibllity of the university.

4. The research potential of the supporting departments of physics, chemistry, geology, and mathematics at the University of Hawaii need further strengthening. The university has made some efforts along these lines and shows evidence that it will continue to do so.

5. There is strong local support and endorsement of the institute outside the university, especially from industrial firms.

6. The university has estimated that the cost of constructing and equipping the physical plant would be about $2.5 million. The cost estimates appear reasonable.

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